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## WHAT AMERICAN ZOÖLOGISTS HAVE DONE FOR EVOLUTION.[1]

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I.

IT would be pleasant indeed if only a lecture or an essay were expected from the presiding officer of the Section; but an address implies a great deal more, and the giver of it is not only expected to be entertaining, where perhaps he never entertained before, but instructive upon grounds upon which, perchance, he has made but partial survey. Among the many questions of sustaining interest, a number of subjects intrude themselves. A general review of the work accomplished since the last meeting of the Association would seem an appropriate subject for discourse. Yet beyond my special studies I feel quite incompetent to scan so broad a field. In this year of Centennial reviews, one might naturally fall into an attempt to sketch the growth of science and the work accomplished within the last hundred years, but that would not only be too vast a field, but would on the whole be unprofitable, since time-boundaries, like the surveyor's lines bordering a State, have no definite existence in Nature. The natural boundaries of oceans and sierras do indeed isolate and impress peculiarities of thought and action upon man, as upon the creatures below him, and for this reason we may with propriety examine the work of our nation in any line of investigation. Never before has the study of animals been raised to so high a dignity as at present. While chemistry could point to its triumphs in the arts, and geology to the revelations of hidden wealth in the rocks, zoölogy was for the most part a mere adjunct to geology, or a means to thwart the

[1] An address delivered at the meeting of the American Association for the Advancement of Science. Read at Buffalo, New York, August, 1876. By Edward S. Morse, Vice-President Biological Section.

ravages of insects. Now, however, it is the pivot on which the doctrine of man's origin hinges. The worlds themselves are too old to study, though the spectroscope reveals the existence of celestial protoplasm as their physical basis. The rocks are too rigid and the time too immense to come within the compass of our minds, but the living facts of evolution are with us to-day in these graceful forms and their constant changes, while the records more or less preserved in past times give us a clew to things hinted at in the earlier changes of present existing forms. It seems, therefore, at the present time, that a review of the work accomplished by American students for the doctrines of natural selection might be acceptable for several reasons, and first among them might be mentioned the fact that thus far no general review of the kind has been made; and, secondly, that with few exceptions all the general works upon the subject are from English or German sources, and filled with the results of work done there oftentimes to the exclusion of work done elsewhere. The oft-repeated examples in support of the derivative theory belong to Europe. The public are familiar with these facts only, and come naturally to believe that these examples alone exist, and from their remoteness do not carry the weight of equally or perhaps more suggestive facts which lie concealed in the technical publications of our own societies. A review of the work accomplished by American students bearing upon the doctrine of descent must of necessity be brief. Even a review of a moiety of the work is beyond the limits of an address of this nature. And for obvious reasons I must needs here restrict it to one branch of biology, namely, zoölogy. For material, the scientific publications of the country have been scanned, and an attempt has been made to bring together the more prominent facts bearing upon natural selection. In this review the zoölogical science of the country presents itself in two distinct periods: The first period, embracing as to time-limits the greatest portion, may be recognized as embracing the lowest stages of the science; it included among others a class of men who busied themselves in taking an inventory of the animals of the country, an important and necessary work to be compared to that of the hewers and diggers who first settle a new country, but in their work demanding no deep knowledge or breadth of view. And so the work to be done in tabulating the animals has more often been done by specialists who neither knew nor cared to know the facts lying beyond the limits of their studies; a work often prompted by the same spirit that one sees among children in the collection of birds'-eggs and postage-stamps. The workers in this class were compared by Agassiz to those who make the brick and shape the stone for the edifice, an indispensable work, but with it was raised not the edifice but an almost insuperable barrier against the acceptance of views more in accordance with reason and common-sense. So thoroughly interwoven with this work were certain conceptions believed to be infallible, that overpowering

indeed has been the argument to render as coadjutors the very men who so thoroughly opposed Darwin at the outset. It seems unnecessary to point out the mode of work adopted by the class above described. Their honor involved as soon as their name had been attached to a supposed new species, and any deviation from the type oftentimes persistently overlooked, what wonder, when every local variety received a new name and that name stamped upon a supposed valid creation—what wonder, I repeat, that whole groups of animals have been so thoroughly scourged by such work that few have the courage to engage in the task of revision?

Emerson's reflections on the science of England in 1847 would apply with far more propriety to our country even at a much later date, where in his words "one hermit finds this fact and another finds that, and lives and dies ignorant of its value." With the noble examples of Dana, Wyman, Leidy, and Burnett, before them, they did not profit. In fact, the labors of these honored men, and early in the century Lesueur and others, gave the country its largest claim to recognition abroad. The second period dates from the advent of Agassiz in this country. With his presence a gradual but entire change took place. He rendered the study a dignity rather than a pastime. No longer were the triflers to fling their loose work before the academies unrebuked. The protests he uttered in this Association were the means of elevating the tone of the communications. In fact, nothing indicates the poverty of our attainments in zoölogy more than an examination of the volumes preceding Agassiz's presence and the succeeding volumes. With his honest repudiation of all that was bad, he frightened away the lighter chaff, and there was but little solid work left to take its place. Agassiz made men, and his example, and the methods of work taught by him, spread to other parts of the country. He brought the American student into intimate acquaintance with the classical work of European naturalists. In his public lectures the names of Cuvier, Von Baer, Leuckart, and others, became familiar. The public caught the enthusiasm of this great teacher, and money was lavishly given by the citizens and the State in aid of his scientific undertakings. Agassiz's earnest protest against evolution checked the too hasty acceptance of this theory among American students. But even the weight of his powerful opposition could not long retard the gradual spread of Darwin's views; and now his own students, last to yield, have, with hardly an exception, adopted the general view of derivation as opposed to that of special creation. The results of his protest have been beneficial in one sense. They have prompted the seeking of proofs in this country, and now our students are prepared to show the results of their work in evidence of the laws of progressive development, and it is mainly this work that I wish to review. So much is claimed for birthplace that, in the way of history, it may not be amiss to call attention to

the fact that the first clear premonition of the theory of natural selection came from this country.

William Charles Wells, born in this country, at Charleston, South Carolina, in 1757, in a paper read before the Royal Society, in 1813, first substantially originated the theory to account for the black skin of the negro. He limits his application to races of men and certain peculiarities of color, correlated with an immunity from certain diseases; in proof of it he cites domesticated animals, and the selection by man in precisely the same line of argument urged by Darwin. In the preface to the last edition to the "Origin of Species," Darwin refers to Wells's essay as entitled to the credit of containing the earliest known recognition of the principle. Dr. Wells first shows that varieties among men as among animals are always occurring, and having cited the way in which man selects certain qualities among domesticated animals and thus secures different breeds, calls attention to the well-known fact that the black as well as the white races are differently affected by certain diseases of the countries which they inhabit. He finds a coincidence between the immunity from certain diseases and the black color of the skin, though why this is so he does not attempt to explain. He thinks that, through the successive survival of dark skins, the dark variety of the human race has become fixed. Referring to the man's selective action regarding domesticated animals, he says: "But what is here done by art seems to be done with equal efficacy, though more slowly, by Nature, in the formation of varieties of mankind fitted for the country which they inhabit." These sentences have such a Darwinian sound that, when we remember they were dragged from obscurity by Mr. Darwin himself, we can share in what a recent writer[1] happily calls "Mr. Darwin's evident delight at discovering that some one else had said his good things before him, or has been on the verge of uttering them." As early as 1843, Prof. Haldeman[2] discussed some of the arguments brought forward by the opponents of the Lamarckian theory, and offered certain views in favor of the transmutation of species. While he does not hint at the laws of natural selection, he recognizes fully the value of varieties and their persistency and ultimate divergence. He says, "Although we may not be able artificially to produce a change beyond a given point, it would be a hasty inference to suppose that a physical agent acting gradually for ages could not carry the variation a step or two farther, so that instead of the original one we will say four varieties, they might amount to six, the sixth being sufficiently unlike the earlier ones to induce a naturalist to consider it distinct."

In the year 1850, Dr. Joseph Leidy, in a paper on entophyta in living animals, wrote as follows: "The essential conditions of life are

[1] Gray's "Darwiniana," p. 284.

[2] *Journal of the Boston Society of Natural History*, vol. iv., p. 368.

five in number, namely: a germ, nutritive matter, air, water, heat, the four latter undoubtedly existing in the interior of all animals." [1] Dr. Leidy affirms his belief that very slight modifications of these essential conditions of life were sufficient to produce the vast variety of living beings upon the globe. The theory of derivation based upon the principles of natural selection demands the following admissions: that species vary, that peculiarities are transmitted or inherited, that a greater number of individuals perish than survive, and that the physical features of the earth are now and have been constantly changing, and that precisely the same conditions never recur. These are admitted facts. Now comes the theoretical part of natural selection, namely, that the varieties which survive are those which are more in harmony with the environments of the time. These propositions, with minor ones, form the theory of Darwin. Lamarck and others had recognized the gradual enhancement of varieties into species, but had not struck the key-note of natural selection, though Wells in the beginning of the century had clearly recognized it in a pertinent example. If we look impartially at these propositions, we need no demonstration to prove the inheritance of characters the most minute, and even the perpetuation of the most subtile features.

On general principles, too, the proposition, that those individuals best adapted to their surroundings survive, need only be stated to be accepted by a reasonable mind. In truth, to deny it would be to deny, as Alphonse de Candolle says, that a round stone would roll down-hill faster and farther than a flat one. Indeed, this eminent botanist affirms that natural selection is neither a theory nor an hypothesis, but the explanation of a necessary fact. The constant physical changes in the past and present condition of the world are incontrovertibly established. It seems, then, that the prime question resolves itself into whether each species as a whole has something inherent which prompts it to vary irrespective of its environments, or whether a correlation can be established between the variation of species and certain physical conditions inducing these variations, and here let me add that of all groups of animals from species through genera to higher divisions, that group of individuals recognized as a species has the most tangible existence. And, as a proof of this, there need only be mentioned the fact that many naturalists, while regarding species as clearly distinct, have on the other hand looked upon classification as an artificial method to facilitate the study, and hence the innumerable schemes and the successive interpolation of subclasses, sub-orders, sub-families, and sub-genera, which simply circumscribed smaller proofs than had before been recognized.

The rapid multiplication of some of these groups has already formed a serious obstacle to the study of systematic zoölogy.

What would good Dr. Mitchell have said if he could have foreseen

[1] "Proceedings of the Philosophical Academy," vol. iii., p. 7.

the generic lists of to-day! In an article on the "Proteus of Lake Erie," he expressed his aversion to multiplying names in zoölogy, and lamented the tendency. He protested as follows, fifty years ago: "By some, these innovations have been so wantonly introduced, as almost to threaten in the end the erection of every species into a distinct genus." [1] Though these words were undoubtedly aimed at Rafinesque, they were none the less prophetic. Whatever may be said of the existence in nature of other groups, there can be no question that species have the most definite existence, and it would seem then that nothing more need be proved for the theory of descent as opposed to the theory of special creation, than the establishment of the fact that species assume the characters of new species, or disappear altogether with a change of surroundings. As examples might be cited, the transplanting of Alpine seeds to warmer regions below, and an accompanying change of the plant into another species before known in the warmer region, or, more remarkable still, the change of a species of *Crustacean* which lives in salt water, to another species with a partial freshening of the water, and this freshening slowly persisted in, the form changing into another genus, and in so doing losing one of its segments. In the first case we see the effect of temperature, and in the second case the physical influence of salt and water in different proportions.

Now, these and hundreds of similar examples can be incontestably proved.

Even the prolonged existence of the form of some animals, like *Lingula*, may be referred to an inherent vitality which enables them to survive changes that caused the death of thousands of others.

In an early discussion of Darwin's theory,[2] Prof. Agassiz cited the persistence of *Lingula* as fatal to the theory, and Prof. William B. Rogers replied that the vital characters of some animals would enable them to survive above others. Ten years later, I had an opportunity of studying living *Lingula* on the coast of North Carolina, and brought specimens home alive in a small jar of water, and kept them in a common bowl for six months without the slightest care. Their power of surviving under changed conditions—their vitality, in other words—seems incredible.[3] (For further details, *see* reference below.)

It has for a long time been suspected that the species of *Mollusca*, described in such profusion in this country, would be reduced when the slightest attention to their habits had been made. Dr. James Lewis [4] long ago observed that a certain species of fresh-water mussel, described as *Alasmodonta truncata*, is only the truncate form of another species, *A. marginata*. From a careful study of the condi-

[1] *American Journal of Science and Arts*, vol. vii., 1829.

[2] "Proceedings of the Boston Society of Natural History," vol. vii., p. 231, December 15, 1860.

[3] Ibid., vol. xv., p. 315.

[4] Ibid., vol. v., p. 121.

tions surrounding the first form in the Mohawk River, he had reason to believe that the rapid currents which pass over it bear along substances that, coming in contact with the exposed edges of the shell, break them down, thus retarding the growth of the shell at this point, and the animal concentrates its growth-powers to the repairs of the broken portion. The same gentleman also shows that the so-called species *Lymnæa elodes*, *catascopium*, and *marginata*, "are modifications of one type or species, influenced by locality and temperature varying the method of development." [1]

A. G. Wetherby [2] calls attention to the variation in form of a group of fresh-water snails, found in the greatest abundance in certain streams of Tennessee and North Alabama. In showing the varied influences they are subjected to he cites the rapid currents of the channels, and the greater liability of the snails being torn from the rocks. He shows that they are exposed in various ways to the effects of these currents, with all their changing impetus of high and low water—exposed also to privation of food from the scouring sand removing the confervæ, upon which they subsist, from the rocks. He takes into account temperature, chemical action, and the like, and says, "No greater vicissitude can be imagined than this growth in an unstable element." Coincident with these diverse conditions he finds an enormous variety of forms, and frankly acknowledges that many of those described as distinct species must be reduced to synonyms.

George W. Tryon, in his large work on the American Melanians, published by the Smithsonian Institution, having finished his manuscript in 1865, says, under date of 1873, when the work was finally published, "A more enlarged acquaintance with fresh-water shells convinces me that a much greater reduction of the number of species than I have attempted must eventually be made."

If we now look upon the definition of a species, as given by a gentleman foremost in the ranks as a describer of species, we find it formulated as follows: A species represents "a primary established law, stamped with a persistent form (a type) pertaining solely to itself, with the power of successively reproducing the same form, and none other;" and this gentleman has not hesitated to base these "primary organic laws" upon the evidence of a single specimen, and in some cases even the fragments of one have offered him a sufficient inducement!

But it has been argued by some that a wide variation may be the case with many species. Prof. Agassiz,[3] at a meeting of the American Academy, reiterated his opinion that what are called varieties by naturalists do not in reality exist as such. He found a great abundance of diverging forms in Echinoderms, which, without acquaintance

[1] "Proceedings of the Boston Society of Natural History," vol. v., pp. 121–128.

[2] *Proceedings of Cincinnati Society of Natural Science*, No. 1, June, 1876.

[3] "Proceedings of the American Academy," vol. v., p. 72.

with connecting ones, would be deemed distinct species, but he found they all passed insensibly into each other.

Prof. Parsons suggested that more extended observations might connect received species by intermediate forms, no less than so-called varieties; and Prof. Gray remarked that the intermediate forms, connecting by whatsoever numerous gradations the strongly divergent forms with that assumed as a type of a species, so far from disproving existence of varieties, would seem to furnish the best possible proof that these were varieties. Without the intermediate forms they would, it was said, be taken for species; their discovery reduced them to varieties, between which (according to the ordinary view), intermediate states were to be expected.

Recognizing, then, the existence of varieties, and of varieties sufficiently pronounced to have led careful naturalists to regard them as distinct species, what shall we say when it is found that these marked forms are correlated with certain physical conditions, many of which have originated within comparatively recent times? Dr. J. G. Cooper,[1] after a careful study of the California land snails, ascertained that "species, sub-species, and varieties, living in cool, damp situations, become more highly developed (but not always larger) than the others; the shell assuming a more compact (imperforate) form, and losing those indications of immaturity referred to, viz., sharp, delicate sculpture, bristles, and angular periphery. These characteristics, however, remain more or less permanently for indefinite periods, and give that fixedness to the various forms, even when living under the same conditions, which enables us to retain them as sub-species differing from varieties in permanency, and from races in not inhabiting distinct regions." It may be added that Stearns, Bland, and Binney, have likewise observed the same peculiar variations associated with aridity.

In a broader field, and compassing different classes, Prof. Spencer F. Baird, Mr. J. A. Allen, and Mr. Robert Ridgway, have severally shown that marked and specific changes are seen in birds and mammals corresponding to differences in their surroundings. Prof. Baird, in a paper entitled "The Distribution and Migration of North American Birds,"[2] has shown that birds in high altitudes and those bred at the North are larger than those born South and at low altitudes; that Western birds of the same species have longer tails than eastern examples, and that the bill increases in size in those birds occurring in Florida as compared with those found north of that State, and that on the Pacific coast the birds are darker in color than those found in the interior.

Mr. J. A. Allen[3] has made a more special study of this matter, and

[1] "Proceedings of the California Academy of Natural Science," vol. v., p. 128.

[2] *American Journal of Science and Arts*, vol. xli., January and March, 1866.

[3] "Proceedings of the Boston Society of Natural History," vol. xv., p. 156.

his work ranks among the most important contributions to this science. Mr. Allen finds that there are marked geographical variations in mammals and birds. He shows that northern mammals of the same species are more thickly and softly furred, and that toward the south the peripheral parts, such as the ears and feet, are more developed. The same law holds good in birds, a diminution in size being observed toward the south, and the individuals being darker in color.

As one goes south he meets with the same species of birds, whose bodies are shorter, but whose beak, tail, and claws, are longer. On the Plains, also, he found the birds with plainer tints, while southward the colors became more intense. On drawing up a table indicating the regions of lighter varieties, and comparing it with a chart of mean annual rainfall, Mr. Allen found the lighter forms occurred in dry regions, and the dark forms in relatively humid regions. To sum up: Mr. Allen finds in latitudinal variation climatic influences affecting color as well as altering the size of bill, claw, and tail, while longitudinal variation usually affects color alone.

He states that these laws are now so well known that a species may be predicted to assume a given color if under certain specific climatic conditions.

Mr. Robert Ridgway[1] has in a similar way called attention to the relation between color and geographical distribution in birds as exhibited in melanism and hyperchromatism, and has shown that red areas "spread" or enlarge their field in proportion as we trace certain species to the Pacific coast, and that in the same proportion yellow often intensifies in tint.

The results of these investigations can be easily understood. Nearly if not quite one hundred and fifty species of birds, which were recognized as distinct, are at once reduced to varieties, though less than twelve years ago they were looked upon as good species, with which no external influence had anything to do. Nearly if not quite a fifth of the number of species of birds have been reduced by the investigations of Baird, Allen, Coues, and Ridgway.

The mammals, through the same study of geographical variation, will have been reduced at least one-fourth. Already Mr. Allen[2] has studied the geographical variation of the squirrels, and the result is that a reduction has been made of one-half the number of species before recognized. Prof. Baird, in his monograph of North American squirrels, reduced the number from twenty-four, as acknowledged by Audubon and Bachman, to ten well-established species and two doubtful varieties. Allen, with still greater advantage in the shape of a mass of material from the Western surveys, reduced the ten species to five species, with seven geographical varieties.

[1] *American Journal of Science and Arts*, vol. iv., December, 1872, p. 454, and vol. v., p. 39.

[2] "Proceedings of the Boston Society of Natural History," vol. xiv., p. 276.

Should it be urged that the present tendency toward reducing species be taken as an evidence that species had not before been properly defined, then it offers a stronger argument still in favor of the fact that species are even more variable than had before been supposed, leaving the greater possibility of larger numbers of these ultimately surviving. Again, the assumption that the limitation of specific variation had not been properly indicated, shows how reprehensible has been the work of some of those who have burdened our literature with their bad species.

The fact is, the work has in a measure been justifiable, and is not to be wholly condemned. The workers in this line have followed the teachings of their masters. A group of individuals removed from an allied group of individuals by an extra dot or darker shade, perpetuating their kind from generation to generation, marked with persistent characters, and in every way coming up to the standard recognized as specific, had the right to be judged as such. It is only when a whole series of forms are collected, and climatic influences are seen to affect these in the same way that they affect other groups of species even in different classes, that the mere influence of moisture and temperature is shown to be the sole cause of many of these supposed specific characters.

Dr. A. S. Packard, in his remarkable monograph of a group of moths, the *Phalænidæ*, published under the auspices of the Hayden Survey, finds that with some species there are changes analogous to those pointed out by Baird and Allen; and while he does not find enough to establish a law, yet to his mind enough is seen "to illustrate how far climatic variation goes as a factor in producing primary differences in faunæ within the same zones of temperature," and he admits that varietal and even specific differences may arise from these climatic causes alone. Dr. Packard, in the same work, under the head of "Origin of Genera and Species," says, "The number of so-called species tends to be reduced as our specimens and information increase." The genera also "are as artificial creations as species and varieties. The work of the systematic biologist often amounts to but little more than putting Nature in a strait-jacket."

An application of the influence of temperature is here proper, as explaining, on a rational ground, the persistence of peculiar arctic forms of animals and plants on the summits of Mount Washington and other high peaks. With a knowledge of glacial phenomena, we are capable of judging the condition of things which must, of necessity, have existed directly after the recedence of the great ice-sheet: its southern border slowly retreating, and, with the encroachment of the warmer zone, the arctic forms dying out, or surviving under changed conditions; but, in high plateaus and mountains, local glaciers flourished for a while, and at their bases arctic forms flourished, and, lingering too long, were ultimately cut off by the retreat

of the main field. This interpretation of arctic forms on high peaks, though attended to by several American naturalists, is not new. Oswald Heer, in discussing the origin of certain animals and plants, coincides with De Candolle that Alpine plants are relics, as it were, of a glacial epoch. Prof. Gray[1] had also independently arrived at the same conclusions, based on a comparison of the plants of Eastern North America and Japan. In the position he maintained regarding the derivation of species from preëxisting ones, he stood far in advance of his brother naturalists in this country, for this was before Darwin's great work had appeared, and before Heer had developed the host of fossil plants from the arctic zone. Mr. S. I. Smith, in speaking of mountain faunæ, points out the gradual encroachment of glaciers, and the drawing down of northern forms; and, as the glaciers retreated, these forms were caught, "the mountain-summits being left as aërial islands." Dr. Packard and Mr. Scudder have severally called attention to the same thing.

Prof. A. R. Grote has more fully dealt with the subject in a paper read before this Association, and in a graphic way shows that the "former existence of a long and widely-spread winter of years is offered in evidence through the frail brown Œneis butterflies, that live on the top of the mountains within the temperate zone." I have been thus explicit, in order to contrast these more rational views with those formerly entertained by eminent naturalists, whose minds were imbued at the time with the idea of special creation. Mr. Samuel H. Scudder[2] read before the Boston Society of Natural History an account of distinct zones of life on high mountains, as illustrated in the insect-life of Mount Washington. He called attention to certain insects which he supposed peculiar to the summit, and not found farther north, though showing a remarkable correspondence to certain arctic forms. Prof. Wyman asked whether all the facts might not be accounted for on the theory of migration northward after a glacial epoch, and Prof. Rogers suggested that the facts might be accounted for on the migratory theory if we added thereto the supposition of subsequent variation induced by isolation. Yet these views were persistently opposed by the other naturalists present. The mass of evidence already contributed, as to the extraordinary variation in color, markings, and size of species coinciding with their physical surroundings, though perhaps trivial in itself, becomes important when the proofs are grouped together, and all bear upon the theory of derivation. So slight a thing as change of food is found to influence certain animals even to a degree usually regarded specific. The late Dr. B. D. Walsh[3] discovered some very curious features among in-

[1] "Memoirs of the American Academy," vol. vi., pp. 377–458 (1859).

[2] "Proceedings of the Boston Society of Natural History," vol. ix., p. 230.

[3] "On Phytophagic Varieties and Phytophagic Species," "Proceedings of the Entomological Society of Philadelphia," vol. iii., p. 403.

sects connected with a change of food. First, he established the fact that insects accustomed to one kind of plant could acquire a taste for another kind, and he has shown that in thus changing the food of the insect a change took place in the appearance of either the larva, pupa, or imago, and sometimes all three stages were affected. Dr. Fitch had observed that changing an insect's larva from the leaf to the fruit affected the appearance of the larva. It would be impossible to give even an abstract of Dr. Walsh's remarkable essay. It may be said, however, that his investigations led him irresistibly to the conclusion that the present species have been derived from preëxisting ones, and in numberless cases he is capable of showing the successive stages from the dawn of a plant-eating variety, where the changes are slightly seen in the larva only, to the plant-eating species in which profound changes are seen in the larva, pupa, and imago.

The minor factors of natural selection, such as protective coloring and mimicry, have been variously illustrated by Mr. R. E. C. Stearns, Dr. Kneeland, Prof. Cope, Dr. Charles C. Abbott, and others. In a special paper on "The Adaptive Coloration of Mollusca," [1] I have endeavored to show not only a wide-spread application of this feature to mollusks, and especially those exposed by the tide, but in some cases a mimicry of inanimate objects, as the accumulation of clay or grains of sand upon the shell.

Wallace's theory of birds'-nests finds interesting confirmations in the observations of Dr. Abbott, who made a special study of a large number of robins'-nests, and found the widest variation among them. He studied also the nests of the Baltimore oriole, where, according to the theory of Wallace, a concealing nest should be made, the bird being exceedingly bright-colored. He found that, away from the habitations of man, the orioles built concealing nests; but in villages and cities, on the other hand, where they were in no special danger from predatory hawks, the nests were built comparatively open, so that the bird within was not concealed.[2]

The differences in the habits of animals of the same species are noticed in different parts of the country, and such facts militate against the idea that certain unerring ways were implanted in them at the outset. Indeed, such facts go to show that these various creatures not only become adapted to their surroundings, but that individual peculiarities manifest themselves. The observations of Dr. Coues, Mr. Allen, and Mr. Martin Trippe, go to prove that certain birds change their habits in a marked degree. In their behavior, too, certain birds, which are wild and suspicious in New England, are comparatively tame in the West. In their resting-places they show wide individual variation.

[1] "Proceedings of the Boston Society of Natural History," vol. xiv., p. 141.

[2] POPULAR SCIENCE MONTHLY, vol. vi., p. 481.

Prof. A. E. Verrill,[1] on the supposed eastern migration of the cliff-swallow, traces historically its first appearance in various places in the East, and is inclined to the opinion that as the country became settled by Europeans the birds left their native haunts for barns and houses, and increased in number to a greater extent than before on account of the protection invariably furnished by man.

Rev. Samuel Lockwood[2] records a curious case of the Baltimore oriole acquiring a taste for the honey-sacs of bees, tearing off the heads of those insects, and, having secured the honey-sacs, rejecting the rest of the body.

Prof. Wyman[3] observes a curious case in Florida of a colt and a number of pigs and cows thrusting their heads under water and feeding on the river-grass, in some cases remaining with their heads immersed for half a minute.

Hon. A. H. Morgan[4] observes the widest difference in the habits of the same species of beaver in the Lake Superior region and in the Missouri, constructing their dams and ways differently, and meeting the varied conditions, not by a blind instinct, but by a definite intelligence manifested for definite purposes.

All of these facts, simple in themselves, yet together go to prove that animals do vary in their habits, and with a persistent change in habits arises the minute and almost insensible pressure to swerve and modify the animal.

So much does the influence of season, with its accompanying peculiarities of food, temperature, humidity, and the like, affect certain animals developing coincidently with its different phases, that it is instructive to note that in certain species of insects two or three different forms occur. Thus Mr. Edwards[5] has in an elaborate way worked up the history of a polymorphic butterfly (*Ephiclides ajax*), showing that there are three forms heretofore regarded as distinct species, which are only varieties of one and the same species, but appearing at different times of the year, and consequently confronted by different influences as to temperature, moisture, food, and the like. These forms are known under the names of *Walshii*, *Telemonides*, and *Marcellus*, and both sexes are equally affected. The first form mentioned represents the early spring type, *Telemonides* the late spring type, and *Marcellus* the summer and autumn type (*see* also Mr. Scudder's paper[6]). If these influences affect species, we should expect to see the greatest variety of forms in a country possessing the widest diversity of conditions.

Some suggestive paths of investigation have been pointed out by

[1] "Proceedings of the Boston Society of Natural History," vol. ix., p. 276.
[2] *American Naturalist*, vol. vi., p. 721. [3] Ibid., vol. viii., p. 237.
[4] " " The American Beaver and his Works."
[5] "Butterflies of North America," part ix.
[6] *American Naturalist*, vol. viii., p. 257.

Prof. N. S. Shaler [1] on the connection between the development of the life and the physical conditions of the several continents, showing first that the greatest amount of shore-line in proportion to the internal areas indicates a greater diversity of surface within.

Another proposition he attempts to establish: that in proportion to the shortness of the shore-lines, or, in other words, to the want of variety in their surfaces, will be the diversity of animal life in the continent. He then proceeds from Darwin's standpoint, and follows out many curious and instructive lines of thought regarding increased amount of influences in diversified surfaces—a level plain having the same conditions throughout, but a mountainous region having for each one thousand feet of elevation a new condition of things, in the form of streams, winds, humidity, and the like. In areas of simple outline and unvarying surfaces we do, in fact, have a less diversity of forms.

Recognizing the mutation of continents through past geologic ages, we again see the accompanying physical changes in not only modifying forms, but in selecting them afterward by succeeding changes.

The widely-diversified nature of the facts bearing on the doctrine of natural selection baffles all attempts at a systematic classification of them. Of such a nature are many of the valuable communications of Prof. Wilder.

At the meeting of this Association [2] he has, among other matters, confirmed in a young lion the discovery of Prof. Flowers that, in the young dog and probably in other carnivora as well, the scapho-lunar bone has at the outset three centres of ossification, and that these really represent the *radiale intermedium* and *centrale* of the typical carpus. By study of a fœtal manatee, Prof. Wilder is able to determine its affinities, and to point out the probable retrograde metamorphosis of some ancient ungulate animal, and that the manatee is widely removed from the whales with which it has been associated.

Mr. William K. Brooks has published a very remarkable paper on certain free swimming tunicates, the *Salpa*, giving for the first time a clear and comprehensive history of certain obscure points, and has at the same time applied the principles of natural selection theoretically in showing the origin of salpa from sessile tunicates, and making clear the peculiar modification of parts which accompany these changes.

In the field of entomology some capital work has been done, both practical and theoretical.

Prof. Riley's demonstration of the yucca-moth is unique in its way. Dr. Engelmann has discovered that the yucca depends upon insects for fertilization; and Prof. Riley, by patient study, not only

[1] "Proceedings of the American Academy," vol. viii., p. 349.

[2] "Proceedings of the American Academy of Arts and Sciences," vol. xxii., p. 301.

discovered the moth which fertilizes the flower, but finds an anomalous change in the maxillary palpi of the insect, by means of which the moth collects bundles of pollen, which it inserts into the stigmatic tube, and during this peculiar act deposits her eggs in the young fruit. Prof. Riley has reasons to believe that this is the only insect engaged in the fertilization of this plant. A mutual dependence is here met with of extreme interest. The yucca unfertilized forms no fruit, and the larva of the moth consequently perishes.

Prof. Augustus R. Grote, in an examination of butterflies, finds successive gradation in their structures, and shows that as these organs "become less serviceable to the insect they become more rigid and in position more elevated above the head in the butterfly, while in the moth they are more whip-like and directed forward." While protesting against the separations which have been made in the order based upon the antennæ, he directs attention "to the real differences in antennal structure between the butterflies and moths, while showing that the antennæ are modified by desuetude in the higher and former group." Prof. Grote,[1] in dealing with a family of moths, the *Noctuidæ*, calls attention to the unequal value of *Acronycta*, and is forced to admit that these differences become clear through the theory of evolution. He says: "Where in *Acronycta* there is a general prevailing uniformity in the appearance in a single group of species and generally broad distinctions between the larval forms, it is a not unreasonable conclusion that these larval differences are gradually evolved by a natural protective law, which intensifies their characters in the direction in which they are serviceable to the continuance of the species."

Those who have believed in types as fixed laws, rigidly impressed at the outset of life, are those also who have recognized in the cells of a honey-bee, as well as in the arrangement of leaves about the axis of a plant, a perfect mathematical adjustment of parts, which were stamped at the beginning, and have so continued to exist without deviation. For nearly two hundred years it has been believed that the instinct of a bee guided it to shape a cell which of all other forms should use the least amount of material. A theory having been established as to the constant shape of a bee's cell, namely, that it was an hexagonal prism with trihedral bases, each face of the base being a rhomb with certain definite angles, a mathematician was given the problem to construct similar cells, and to determine the best possible form with the use of the least amount of material. The coincidence between theory and observation and experiment was so remarkable as to settle apparently for all time the question as to the perfectly-implanted instinct of the bee with its unconscious power of accurate work. Prof. Jeffries Wyman,[2] to whose memoir I am indebted

[1] "Proceedings of the Buffalo Society of Natural Science," vol. i., p. 130.

[2] "Proceedings of the American Academy," vol. vii., p. 68.

for the above facts, has by an ingenious study of the cells of bees shown, first, that, a cell of this perfection is rarely if ever attained. Furthermore, that, while the honey-cells "are built unequivocally in accordance with the hexagonal type, they exhibit a range of variation which almost defies description;" that the worker-bees, from incorrect alignment and other causes, build cells, the measurement of which shows the widest limit of variation; that the drone-cells are liable to substantially the same variations, while the transition-cells, namely, those in which drones and worker-cells are combined in the same piece of comb, are extremely irregular. As the drone-cells are one-fifth larger than worker-cells, "a transition cannot be made without some disturbance in the regularity of the structure." And Prof. Wyman states distinctly that the bees do not have any systematic method of making the change, adding that "the cell of the bee has not that strict conformity to geometrical accuracy claimed for it," and the assertion, like that of Lord Brougham, that there is in the cell of the bee "perfect agreement between theory and observation, in view of the analogies of Nature, is far more likely to be wrong than right, and his assertion in the case before us is certainly wrong." Prof. Wyman closes his essay by saying that "much error would have been avoided if those who have discussed the structure of the bee's cell had adopted the plan followed by Mr. Darwin, and studied the habits of the cell-making insects comparatively, beginning with the cells of the humble-bee, following with those of the wasps and hornets, then with those of the Mexican bees, and finally with those of the common hive-bee; in this way they would have found that, while there is a constant approach to the perfect form, they would at the same time have been prepared for the fact that even in the cell of the hive-bee perfection is not reached. The isolated study of anything in Nature is a fruitful source of error."

The remarkable ingenuity, so characteristic of Prof. Wyman's experiments, is fully shown in this memoir. He made plaster-casts of the comb, and then sawed transverse sections, and by slightly heating the plaster the wax was melted and absorbed, leaving the delicate interspaces representing the partitions. From these sections electrotypes were taken, and thus the veritable figures were used to illustrate the absolute structure of the comb. The results of these brilliant researches were published in the "Proceedings of the American Academy of Sciences."

[*To be continued.*]

changes in the direction of the fibres of the wood as the longer length of the trying-plane could not conveniently deal with. Hitherto, we have regarded the plane as arranged with a "guide principle" which shall always repeat a straight, level surface. The guide may, however, be the counterpart of any required surface. The plane made of iron, now in my hand, has an elastic steel sole, which, by means of adjusting screws, enables a workman readily to convert a straight-faced sole into one either concave or convex. This is an American production (*see* Fig. 10).

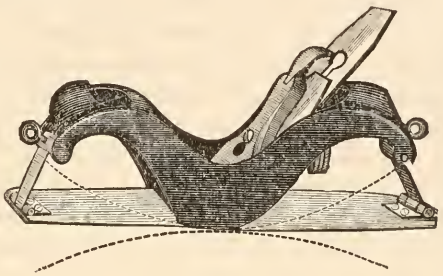

Fig. 10.

There is also in this and other planes a mode of fixing the iron which deserves more general adoption than it receives, viz., by a cam-action. It will often be noticed that, where the holding-wedge binds on the box of the plane in our ordinary planes, the wood has split. This arises from a commendable but, in this case, too strict a care for a good fit; hence the wedge is made tight where it should be slack.

## WHAT AMERICAN ZOÖLOGISTS HAVE DONE FOR EVOLUTION.[1]

By Professor EDWARD S. MORSE.

II.

IN the "Memoirs of the American Academy of Sciences" may be found a profound mathematical essay "On the Uses and Origin of the Arrangement of Leaves and Plants,"[2] by the lamented Chauncey Wright. After discussing the laws of phyllotaxy, and showing that the botanist is wrong in supposing this a law at the outset, Mr. Wright states "one of the utilities, so to speak, in the apparently

[1] An address delivered at the meeting of the American Association for the Advancement of Science. Read at Buffalo, New York, August, 1876, by Edward S. Morse, Vice-President of Biological Section.

[2] "Memoirs of the American Academy," vol. ix., p. 379.

undeviating arrangement of leaves, to be the distributing of leaves most rapidly and thoroughly around the stem, exposed more completely to light and air, and provided with greater freedom for symmetrical expansion, together with more compact arrangement of bud;" and he asks, "What has determined such an arrangement of vital forces?" Theory of types would say, their very nature, or an ultimate creative power. Theory of adaptation would say, the necessity of their lives, both outward and inward; or the conditions, both past and present, of their existence.

Whatever tends to show modification in the markings, color, size, food, or change in the variety of habits manifested by animals, furnishes just so many indications of the unstable character of what had before been considered stable, and gives an infinitely wider field for those unconscious selections whose operations are coincident with every change in the physical features of the earth. On the theory of derivation additional confirmation is given to the deductions of geologists based upon the stratigraphical and paleontological evidences of the rocks. The survival of a marine crustacean in the deeper waters of Lake Michigan, as discovered by Stimpson, coupled with similar occurrences in the lakes of Sweden, suggests the past connection of these waters with the ocean. In the same way the persistence of arctic forms on high mountain-tops indicates the existence in past times of wide-spread glacial fields. The interesting discoveries of Mr. Ernest Ingersoll, in the Rocky Mountains, of the occurrence of two species of marine mollusks and living crabs belonging to marine forms, and tiny air-breathing mollusks peculiar to the Gulf coast and West Indies, point as distinctly to the past connection of that region with the ocean as the records of marine life left in the rocks. And more than this, the survival of these few forms gives us a conception of the thousands of animals which have succumbed to the changed conditions. Connected with the evidences of recent elevation of this region are the discoveries of Marsh in finding that, when the gill-bearing salamander *Siredon* is brought down from the colder waters of the Rocky Mountains to the warmer waters below, a complete change takes place in a loss of the gills and the conversion of the animal into the air-breathing genus *Amblystoma.*

This exhibits on a wider scale the experiments often performed in keeping tadpoles in the dark and cold, and indefinitely retarding their development, thus forcing them, as it were, to retain their earlier condition. Among the many millions of individuals of Amblystoma, some must have presented the anomaly of a premature development of their ovaries before the larval stage had passed away (similar cases being observed among insects), and thus it has been possible for them to perpetuate their kind in this stage. The Axolotl, having the longest persisted in this mode of growth, has become, as it were, almost fixed in these retrograde characters, only a

few examples being known in which the creatures have lost their gills and assumed the mature characters of Amblystoma, but with Siredon a change takes place with a proper change of surroundings.

To American students we are indebted for most valuable contributions regarding the effect of cave influences on animals living within their boundaries. Looking at the cave fauna with its peculiar assemblage of animals, it would seem that here, at least, the question as to the effects of certain external influences, or the absence of others in modifying structure, might be found.

Many years ago the editors of *Silliman's Journal* addressed a letter to Prof. Agassiz respecting the blind fishes of the Mammoth Cave, and asked his opinion as to whether their peculiar structure was due to their cave life, or whether they had been specially created. Agassiz's [1] reply is consistent with his belief. He says, "If physical circumstances ever modified organized beings, it should be easily ascertained here." He then expresses his conviction that "they were created under the circumstances in which they now live, within the limits over which they range, and with the structural peculiarities which characterize them at the present day," adding frankly, however, that these opinions are mere inferences.

With the contributions on cave insects by the eminent zoölogist Schiödte, and our own naturalists as well, we have now overwhelming proof that the blind fishes and numerous other cave animals are marked with peculiarities impressed upon them by the unusual environments to which they have been subjected.

In a work on the animals of the Mammoth Cave, by Dr. A. S. Packard and Prof. Putnam, the first-named writer quotes the results of Schiödte, wherein he shows the existence of twilight animals in which but slight modification occurs, while in darker places the changes become more profound.

Dr. Packard [2] sums up the results of his work as follows: "We then see that these cave animals are modified in various ways, some being blind, others very hairy, others with long appendages; all are not modified in the same way in homologous organs, another argument in proof of their descent from ancestors whose habits varied as their out-of-door allies do at present."

Prof. E. D. Cope,[3] in an article on the fauna of Wyandotte Cave, in commenting on the loss of eyes in cave animals from absence of light, and consequent disuse, says that, to prove it, "we need only to establish two or three propositions: 1. That there are eyed genera corresponding closely in other general characters with the blind ones. 2. The condition of the visual organs is in some cave type variable. 3. If the abortion of the visual organs can be shown to take place coincidently with general growth to maturity, an important

[1] *American Journal of Science*, second series, vol. xi., p. 128.

[2] "Life in the Mammoth Cave," p. 27. [3] *American Naturalist*, vol. vi., p. 415.

point is gained in explanation of the *modus operandi* of the process." He then proceeds to point out a number of related genera in which the external ones present eyes, while the cave forms are blind. As to variability, he cites the blind siluroid fish from Conestoga, Pennsylvania, showing that, while all of several specimens were blind, the degree of atrophy was marked not only in different fishes, but even on different sides of the same fish. In some the corium was perforate, in others it was imperforate. In some the ball of the eye was oval, in others collapsed.

We have in the meagre fauna of the caves convincing proof of the gradual undoing of parts—so to speak—on the withdrawal of influences favorable to them; even so exquisite a structure as the eye as a result of selection almost inconceivable, yet not only becoming rudimentary, but almost disappearing, by the withdrawal of those influences which were in part conducive to its building up. So distinct are these undoing stages that, were we sure of the stable variability of all of them, we could with certainty indicate the relative age of each cave inhabitant.

Prof. Alpheus Hyatt and Prof. E. D. Cope almost simultaneously established a number of propositions relating to certain large groups of animals which had never been recognized before. The theory of acceleration and retardation in which certain groups acquire rapidly new characters, while corresponding groups acquire the same characters more slowly, forms a portion of the theory of these naturalists. Prof. Hyatt has shown among Ammonites a parallel between the life-stages of the individual and similar stages in the group based upon an examination of suites of specimens as studied by him in Europe and America. It is utterly impossible to do the slightest justice to the thoroughly original views of these gentlemen without the aid of explanatory diagrams. While reluctantly abandoning the attempt, I must at the same time express the regret that neither of these investigators has seen fit to present to the public an illustrated and simple outline of the main features of their theories and the facts: Prof. Cope basing in part his propositions on groups of animals, many of which comprise fossil forms brought to light in the West, of which but few restorations have yet been made; and Prof. Hyatt basing his work on fossil Ammonites from the Jurassic and adjacent beds of Europe, of which but one complete collection is to be found in this country.

Surely, with this unfamiliar material, an excuse may be offered in not attempting a popular presentation of propositions and laws, some doctrinal and others theoretical, which must yet be looked upon as profound and permanent additions to the philosophy of evolution. A reference may be made to Prof. Cope's essays, entitled "Origin of Genera," "On the Method of Creation of Organic Types," "Consciousness in Evolution," "On the Theory of Evolution," and numer-

ous other memoirs from which may be gathered the author's views on the subject. The essays of Prof. Hyatt, "On the Parallelism between the Different Stages of Life in the Individual and those in the Entire Group of the Molluscan Order Tetrabranchiata," "Reversions among Ammonites," "Evolution of the Arietidæ," "Genetic Relations of the Angulatidæ," "Abstract of a Memoir on the Biological Relations of the Jurassic Ammonites," are altogether too technical to condense into an address of this nature. It need hardly be mentioned that in these memoirs invaluable contributions are made to the doctrines of natural selection. And now we come to the most difficult part of our work: to compass within the limits of a few pages the magnificent discoveries of Leidy, Marsh, and Cope, in the rich fossiliferous beds of the West. The wonders are so unique and varied; they have been poured upon us with such prodigality of material and illustration, that one is baffled in an attempt to compass their characters, or to picture them as realities. When Darwin offered the imperfection of the geological record as possibly accounting for the absence of intermediate forms which might have existed, he was at once met by a series of protests so strenuous, and at the same time so specious, that they had their full weight in staying the force of that prophetic chapter. Darwin, in this chapter, distinctly stated that not only were there forms which had never yet been seen, owing to the imperfection of the geological record, but that time might possibly bring them to light, and, when discovered, we should have revealed to us intermediate characters which would connect widely-separated groups as they are recognized to-day.

Behold the prophet! Animals have been discovered, not only showing the characters of two widely-separated groups, but in some cases of three groups as they now appear. How distinct the hoofed quadrupeds, the carnivora, and the rodents, appear to-day! Yet here are discovered ancestors of these widely-separate groups, in which are contained in one individual the characters of all three! Of the ungulates with the perissodactyle foot, there have been discovered a large number of tapiroid forms allied to Paleotherium; others which, like Anchitherium, wonderfully fill the gap between the horse and forms lower down; a large suite of rhinocerotic creatures of strange character and enormous size; a great number of species of three-toed horse, some no larger than foxes, and with these a perplexing maze of deer, antelopes, sheep, camels, hippopotami, and pig-like animals, ruminant-like beasts, some of them not larger than an ordinary squirrel: a curious group, comprising a large number of species with characters intermediate between the pigs and ruminants. Prof. Flower, the great English osteologist, confesses that these forms completely break down the line of demarkation between them, and adds that "a gradual modification can be traced in the characters of the animals of this group, corresponding with their chronological

position, from the earlier more generalized to the latest comparatively specialized forms, thus affording one of the most complete pieces of evidence that are known in favor of a progressive alteration of form, not only of specific, but even of generic importance through advancing ages." The probable home of the Camelidæ has been revealed in the discovery of llama-like creatures, gigantic mammals, in some cases exceeding the elephant in size, but with a diversity of characters hitherto unseen either in recent or fossil forms, combining as they did the characters of perissodactyle and proboscidian.

A numberless variety of Carnivora, many of them embracing the most generalized groups, have been brought to light, such as creatures between the wolf and the opossum, generalized dogs, and sabre-toothed cats.

A great many species belonging to the Rodentia, Insectivora, and Chiroptera, have been identified; still more wonderful is a group of creatures so unlike any beast heretofore known that Prof. Marsh has made a new order to include them under the name of *Tillodontia*. They combine the characters of several distinct groups, namely, the carnivores, ungulates, and rodents, and some of them in size equaling the tapir. Of great interest also is the discovery of fifteen new genera, belonging to low forms of primates. All of these creatures, embracing hundreds of species, are generalized in a high degree. New orders have been erected to embrace some of them. One has only to understand the specialization of modern animals to appreciate the generalized character of these early forms.

Prof. Marsh has shown that all the ungulates in the Eocene and Miocene had upper and lower incisors; and, again, that all the Eocene and Miocene mammals, including the Carnivora, had two of the wrist-bones, the scaphoid and lunar, as distinct bones.

The class of birds so long represented as a closed type can no longer occupy that isolated position. The proper interpretation of archæopteryx has, in the discoveries of Marsh, new interest. He has discovered a number of species of birds, for which a new sub-class is made. This sub-class will embrace two sub-orders, one in which the creatures had teeth contained in grooves in the jaws; the other had true teeth in the sockets. The first were swimming-birds of gigantic size, with rudimentary wings; the second embraced small birds, with powerful wings and bi-concave vertebræ.

Prof. Cope has also brought to light a remarkable gigantic bird from the Eocene of New Mexico; its size indicates a species with feet twice as large as those of the ostrich. He shows it to be distinct from any of the genera of *Struthionidæ* or *Dionornithidæ*. Besides all these wonders, a host of new forms of reptiles and fishes have been discovered by these indefatigable explorers—huge pterosauria discovered by Marsh with a spread of wing of twenty-four feet; and of more special interest is the fact that no trace of teeth can be found in the jaws.

It is impossible for me to more than allude to these remarkable additions to our knowledge of these early forms, and until they have all been figured with natural outlines, and perplexing questions as to priority in discovery rectified, it will be difficult in some cases to accredit individual work. But in the light of these profound revelations, how blind seem the attempts to establish a classification on the forms heretofore familiar to us, and to rear these into circumscribed groups between which it was asserted no forms of intermediate kinds were to be expected! With the twenty-five or thirty species of fossil horses at our command, some with four toes, others with three, in various stages of reduction, it is interesting to bring back to mind the earnest Geoffroy St.-Hilaire painfully endeavoring to trace the genealogy of the horse, with a few widely-separated forms of extinct mammals as his only guide in the work.

The special investigations of Marsh and Leidy reveal an almost unbroken line from our present horse with its simple toe, and two rudimentary metatarsals in the shape of the splint-bones, to a creature in which metatarsals support rudimentary toes, and still other forms in which these rudimentary toes are working-toes, and below that again another form in which a fourth toe is seen as a rudiment, till forms are reached in which all the toes rest on the ground. It is still more striking to study attentively those earlier generalized horses with four toes, and follow the successive reduction in the number of toes as the later formations are reached, till in the latest deposits and at present we have the modern specialized horse with but a single toe, the lost toes represented by two slender bones hidden beneath the flesh. And now comes crowning proof that our modern horse has been derived from some three-toed progenitor, for in certain instances horses have come into existence with splint-bones developed into sturdy bones sustaining at the extremities phalangeal bones, and outside accessory hoofs! Such freaks of Nature demand an explanation. They receive a rational one through the theories of Darwin. Without the law of reversion, we are left in blind bewilderment.

While all these facts in overwhelming array testify to the extreme mutability of forms, induced oftentimes by apparently the most trivial of causes, and set at rest the question as to the fixedness of species, they show at the same time the richness of that store from which by natural selection forms may be selected.

Realizing the uniformity of Nature's laws, the human mind bravely asks, "Do these wonderful interpretations throw any light upon the origin of man?"

Rigidly adhering to the inductive method, science is prepared to show that man did not appear suddenly and free from those animal proclivities and passions which make him a sinful creature, but that he has risen from a lowly origin, and his passions and desires, but feebly repressed, may be as surely traced to ancestral traits, as the

aberrant muscles in his structure may be recognized in some degraded progenitor. And in proof of this there is established a series of facts of precisely the same nature as is seen in those discoveries which link the horse in an almost unbroken line to earlier and more generalized animals.

It is instructive to read the discussions in relation to man's position in Nature as represented by Agassiz, Morton, and others.

The position that these eminent men were justified in taking shocked the Church, and received from her the same vigorous denunciations that Darwin was forced to bear at a later day.

The systematist, in formulating the separate species and genera of the apes and monkeys, was early led to see that man also in various parts of the world presented differences quite as striking, and if it were assumed, as indeed it was, that the peculiarities among men were only varietal, then it could be claimed with equal emphasis that the differences among apes were only varietal. Agassiz, in his keen grasp of things, readily saw this, and, since the races of men revealed differences just as specific in their characters as the animals immediately below them, he was forced to admit the plurality of origin of the human race. He says:

"Unless we recognize the differences among men, and we recognize the identity of these differences with the differences which exist among animals, we are not true to our subject, and, whatever be the origin of these differences, they are of some account; and if it ever is proved that all men have a common origin, then it will be at the same time proved that all monkeys have a common origin, and it will by the same evidence be proved that man and monkeys cannot have a different origin."

He confesses that he "saw the time coming when the position of the origin of man would be mixed up with the question of the origin of animals, and a community of origin might be affirmed for them all." With these convictions it is not surprising that he should have been led to express the opinions regarding the diversity of the human race that we find recorded.

Agassiz, in the meetings of the American Academy, repeatedly and in various ways illustrated the diversity of the human race. In one place he alludes to the difficulty in defining the species of man, and says the same difficulties occur in defining the species of anthropoid apes. We quote from the records:

"The languages of different races of men were neither more different nor more similar than the sounds characteristic of animals of the same genus; and their analogy can no more be fully accounted for on any hypothesis of transmission or tradition than in the case of birds of the same genus uttering similar notes in Europe and America."—("Proceedings of the American Academy," vol. iii., p. 6.)

Again, in a later volume, he expresses a general disbelief in the supposed derivation of later languages from earlier ones. He re-

garded each language and each race as substantially primordial, and ascribed their resemblances to a similarity in the mental organization of the races.

This extract illustrates the extremity to which one is logically driven if he accepts the hypothesis of special creation, and these words are quoted, not with the belief that at the present time they would have been uttered, but as illustrating the necessary admissions with the theory of plurality of origin. In precisely the same manner that Whitney, Müller, and other eminent philologists, have shown the outgrowth of present existing languages from primitive forms of language, so science is prepared to show the outgrowth of present men from primitive forms of animals. Agassiz was bitterly assailed by the Church for the bold attitude he assumed regarding the plurality of origin of the human race, though now that science will show that after all man has originated from a common centre, it seems no better satisfied. The facts bearing on man's lowly origin have been fully contributed by American students, and, as all intelligent men understand the bearing of these facts on the question, it is only necessary to allude to them here. If man has really been derived from an ancestor in common with the ape, we must expect to show— 1. That in his earlier stages he recalls certain persistent characters in the apes; 2. That the more ancient man will reveal more ape-like features than the present existing man; and, 3. That certain characteristics pertaining to early men still persist in the inferior races of men.

Prof. Wyman[1] points out certain resemblances between the limbs of the human embryo and the permanent condition of the limbs of lower animals. In some human embryos about an inch in length he found that the great-toe was shorter than the others, and, instead of being parallel to them, projected at an angle from the side of the foot, thus corresponding with the permanent condition of this part in the Quadrumana.

In some observations made on the skeleton of a Hottentot, Prof. Wyman[2] calls attention to the complete ossification of the nasal bones, no trace of a suture remaining. This was more noticeable as the individual was young, and the other bones were immature, and had an interest "in connection with the fact that the nasal bones are coössified at an early period in the monkeys and before the completion of the first dentition in gorillas and chimpanzees." Careful measurements of the pelvis also revealed quadrumanous features, though "the resemblance is trifling in comparison with the differences."

In a study of the crania, Wyman[3] found differences in the relative position of the *foramen magnum*. In the North American Indian this opening was farther back than in the negro, while some crania from Kauai presented this opening still farther back than in the

[1] "Proceedings of the Boston Society of Natural History," vol. x., p. 185.
[2] Ibid., vol. ix., p. 352.
[3] Ibid., vol. xi., p. 447.

Indian; and more than half the lot from Kauai had the peculiarity in the nostrils first pointed out in the negro by Dr. John Neil, of Philadelphia, namely, the deficiency of the sharp ridge which forms the lower border of the opening. In its place is a rounded border, or an inclined plane.

This feature occurs very frequently in different races, but more rarely in Europeans. It is, however, never absent in the apes. Prof. Wyman, in studying the characters of certain ancient crania from a burial-place near Shell Mound, Florida, observed the *foramen magnum* quite far back, and remarks on the massive character of the bones composing the skull, the parietal being nearly twice the thickness of ordinary parietals, while the general roughness of the surfaces for muscular attachments on the hinder part of the head is very striking.[1]

In certain measurements of synostotic crania, Prof. Wyman found that the length of the parietals was twenty-four millimetres above the average, the parietals being lengthened from before backward, the frontal and occipital being but slightly augmented. Now, in the much-discussed Neanderthal skull, wherein it is urged by Dr. Davis that it is a synostotic skull, though denied by Huxley, Wyman shows that the parietals measure nine millimetres *below* the average, which is certainly against the view that the Neanderthal skull is synostotic.[2]

In an essay entitled "Observations on Crania and Other Parts of the Skeleton," Prof. Wyman shows that the relative capacity of the skull "is to be considered merely as an anatomical and not as a physiological characteristic,"[3] a most important distinction certainly in considering the large capacity of certain ancient skulls, since we must know the quality as well as the quantity in order to assume the intellectual position of the races. In this essay are also quoted the results of a large series of measurements made by Dr. B. A. Gould, in which it is shown that the arms of the blacks are relatively longer as compared with the whites, in this respect approaching the higher animals, a confirmation of the observations made by Broca, Pruner Bey, Lawrence, and others.

The perforation of the humerus, which occurs in the apes quite generally, was found to occur rarely in the white race. Of fifty humeri, Wyman found but two perforated, while of Indian humeri he found thirty-one per cent. perforated. In some of the remains of ancient men there has been found a remarkable lateral flattening of the tibia, unlike anything found at present, but always characteristic of the earliest races. These tibiæ have received the name of platycnemic tibiæ.

[1] "Fourth Annual Report of the Peabody Archæological Museum. Cambridge."

[2] "Proceedings of the Boston Society of Natural History," vol. xi., p. 455.

[3] "Fourth Annual Report of the Peabody Archæological Museum."

Wyman[1] quotes Broca as saying that the measurements of these tibiæ resemble the ape, and, what is more striking, in a small number of instances "the bone is bent and is strongly convex forward, and its angles so rounded as to present the nearly oval section seen in the apes." The occurrence of these platycnemic tibiæ has been noticed by several investigators. They have been obtained from the mounds of Kentucky by Mr. Carr, Mr. Lyon, and Prof. Putnam. Prof. Wyman found them in Florida mounds. To Mr. Henry Gillman, of Detroit, science is indebted for the discovery of the flattest tibiæ ever recorded, exceeding even those discovered in Europe. Mr. Gillman has opened a number of mounds along the Detroit and Rouge Rivers in Michigan, and assiduously studied the characters of these remains, which indicate a very ancient race of men. Many of these tibiæ he has sent to the Peabody Archæological Museum at Cambridge. Associated with these remarkable tibiæ he found large numbers of perforated humeri.

At the Detroit meeting of the Association, Prof. W. S. Barnard showed that the muscles which move the fingers and toes have been developed from one common muscle, and, in studying the various degrees of specialization of the muscles which move the hand and foot in the gorilla and lower apes, he finds that in the foot "man remains a creature of the past not modified by that which makes him a man, the brain. The hand has been modified and perfected by its services to the brain." Prof. Barnard also contributed another essay, entitled "Comparative Myology of Man and the Apes." From very careful studies he is led to believe that the relative position of the origin of the muscles is more constant than that of their insertions. In this examination he brings to light a muscle which Traill dissected in the higher apes, and which he called the *scansorius*, and this was supposed to have no representative in man.

Traill was followed by Wyman, Owen, Wilder, and Bischoff, who, in a controversy with Huxley, argued from this muscle against the simian origin of man. Mr. Barnard now shows that Traill was mistaken, and that other naturalists were misled by the weight of his authority. What Traill interpreted as the *gluteus minimus* is the *pyriformis*, and what he figured as a new muscle separating the apes from man, the *scansorius*, is the *homologue* of our *gluteus minimus*.

From gradually accumulating data, in regard to microcephalic skulls, it would seem as if Carl Vogt were right in judging them to be cases of reversion. Prof. Wyman says, in regard to a microcephalic skull from Mauritius, that, "taking together the high temporal ridges, the union of the temporals with the frontals, the projection of the jaws, the narrow and retreating forehead, the small capacity, and the form and proportions of the nasal openings, the general resemblance to that of an ape is most striking, and seems to justify Vogt's expres-

[1] "Fourth Annual Report of the Peabody Archæological Museum."

sion of a man-ape, it being understood that the skull we are describing is not a natural, but an anomalous formation."[1]

It would be difficult to imagine, indeed, that mere reduction in the size of the brain, through arrest of development, should produce a series of characters so closely resembling the apes as is found to be the case in so many widely-separated examples. Thus, in the Mauritius microcephalic skull the capacity is only twenty-five cubic inches. The jaws are extremely prognathous, the zygomatic arches stand out wide and free, and the temporal ridges approach within one and a quarter inch. If such examples should prove to be veritable cases of reversion, then we have a parallel in the startling appearance of the long-lost rudimentary toes of the horse, traces of which are only seen in the hidden splint-bones. In the "Seventh Annual Report of the Archæological Museum," Prof. Wyman describes a microcephalic skull from the ancient *huacals* of Peru. Its capacity is only thirty-three cubic inches; "the frontal bone is much slanted backward, has a decided ridge corresponding to the frontal suture, and is slightly concave on each side of it."

Wyman states that the bones of the head are well formed, though, from the diminutive size of the brain, idiocy must have existed.

Associated with the remarkable collection of platycnemic tibiæ and perforated humeri discovered by Mr. Henry Gillman, we should have expected some anomalous forms of crania, and in this expectation we are not disappointed.

In company with two skulls which appear to be normal, Mr. Gillman discovered one of most remarkable proportions. Wyman considers it a case of extreme individual variation, and not the result of artificial deformity. The skull in question has only a capacity of fifty-six cubic inches. The average capacity of Indian crania, according to Morton's measurements, being eighty-four cubic inches, and the minimum capacity being sixty-nine cubic inches, the skull of Gillman is therefore thirteen cubic inches less than the smallest Indian skull heretofore described. But more extraordinary still is the approximation of the temporal ridges. While in ordinary crania the separation of these ridges is usually from three to four inches, and never less than two inches, in this unique skull from the Detroit River mound the ridges in question approach within three-quarters of an inch, in this respect, as Wyman says, presenting the same condition as that of the chimpanzee. A rounded median crest can be distinctly seen and felt between these ridges, and the skull is markedly depressed on each side for the passage of the powerful mastoid muscles.

Is this, too, a case of partial reversion? Such extraordinary forms as the Neanderthal and Engis skulls, and the one above cited, with the La Naulette and other lower jaws, could not have been uncommon in those early days, since the chances against finding them

[1] "Seventh Annual Report of the Peabody Archæological Museum."

would be simply enormous, unless, indeed, they were of common occurrence. Looking at these remains as at the remains of other mammals, we must admit either that these low characters represent retention of ancestral peculiarities, or that they are cases of reversion. In considering the Neanderthal skull, with its retreating frontal, its enormous frontal crest, and other anthropoid characters, Huxley is led to say that at most there is "demonstrated the existence of a man whose skull may be said to revert somewhat toward the pithecoid type."

To a mind unbiased by preconceived opinions, and frankly willing to interpret the facts as they stand revealed by the study of these ancient remains the world over, the evidence of man's lowly origin seems, indeed, overwhelming.

Looking at the whole question impartially, we find that among recent men there are high types as well as low types, with a variation so great as to have induced Agassiz, Morton, and others, to consider them specific. And while, as Wyman asserts, no one race possesses all the low characters, yet with the relatively long arms, the tendency of the pelvis to depart from the normal proportion, and numerous other facts of like significance, there are yet retained among some of them more resemblances to the higher apes than can be found among others.

Prof. Cope, not content with tracing man back to some ape-like progenitor, has, in a suggestive way, considered man's relations to the Tertiary mammalia. In a communication to the Association at Detroit, on this subject, he prefaced his paper by saying that in the doctrine of evolution two propositions must be established: 1. That a relation of orderly succession of structure exists, which corresponds with a succession in time; 2. That the terms (species, genera, etc.) of this succession actually display transitions or connections by intermediate forms, whether observed to arise in descent, or to be of such varietal character as to admit of no other explanation of their origin." He shows that the primary forms of mammalia are strongly indicated in the structure of the feet, and also in the character of the teeth. In recent land-mammals there are several types of foot to be recognized, the many-toed plantigrade, the carnivorous, the ox, and the horse types. Among the earlier types of the Eocene, he finds the most generalized type in the Coryphodon of Owen (Bathmodon of Cope). This creature was plantigrade, with a short calcaneum, and an imperfect hinge for the foot. From this generalized form he traces a line of succession of intermediate forms to the horse on the one hand, and the ox on the other.

The Coryphodon was one of the earliest known mammals, while the horse and the ox preceded man by a single geological period. Without entering into a technical description of the successive forms presented by Prof. Cope, we may quote his words wherein he shows

that "the mammals of the Lower Eocene exhibit a greater percentage of types that walk on the soles of their feet, while the successive periods exhibit an increasing number of those that walk on the toes; while the hoofed animals and Carnivora of recent times nearly all have the heel high in the air, the principal exceptions being the elephant and bear families." After presenting the gradual osteological changes of the foot, from the earlier types to the later ones, through several lines of descent, considering also the teeth as well, he says: "The relation of man to this history is highly interesting. Thus, in all generalized points, his limbs are those of the primitive type, so common in the Eocene. He is plantigrade, has five toes, separated tarsals and carpals, short heel, rather flat astragalus, and neither hoofs nor claws, but something between the two; the bones of the forearm and leg are not so unequal as in the higher types, and remain entirely distinct from each other, and the ankle-joint is not so perfect as in many of them. In his teeth his character is thoroughly primitive. . . .

"His structural superiority consists solely in the complexity and size of his brain. A very important lesson is derived from these and kindred facts. The monkeys were anticipated in the greater fields of the world's activity by more powerful rivals. The ancestors of the ungulates held the fields and the swamps, and the Carnivora, driven by hunger, learned the arts and cruelties of the chase. The weaker ancestors of the Quadrumana possessed neither speed nor weapons of offense and defense, and nothing but an arboreal life was left them, where they developed the prehensile powers of the feet. Their digestive system unspecialized, their food various, their life the price of ceaseless vigilance, no wonder that their inquisitiveness and wakefulness were stimulated and developed, which is the condition of progressive intelligence"—adding that "the race has not been to the swift, nor the battle to the strong." Prof. Cope shows in this case that "the survival of the fittest has been the survival of the most intelligent, and natural selection proves to be, in its highest animal phase, intelligent selection."

Prof. Fiske has in a clearer way shown that when variations in intelligence became more important than variations in physical structure, then they were seized upon, to the relative exclusion of the latter.

It is intelligent strength, other things being equal, that conquers the savage, and the gradual selection of the best and biggest brains is not seen alone in man.

In one of the most significant discoveries of Prof. Marsh, the mammalia are found to show an increase in the size of the brain coincident with their succession in the rocks.

One of the most extraordinary mammals from the Tertiary beds of the West is the Dinoceras, with its rhinoceros and elephant characters, its skull ornamented with prominent tubercles, its unique den-

tition, embracing large cutting tusks, and altogether forming a beast like the fabled monsters of old.

A study of its cranial cavity, made by Prof. Marsh, shows that its brain was proportionally smaller than that of any known mammal. Indeed, it was almost reptilian, and of such diminutive size that it could have been drawn through the neural canal of all the presacral vertebræ. Prof. Marsh has followed up this discovery with the most important results, and is now prepared to state the following conclusions:

1. That all the Tertiary mammals had small brains.

2. There is an increase in the size of the brain during this period.

3. This increase was mainly confined to the cerebral hemispheres or higher portion of the brain.

4. In some groups the convolutions of the brain have gradually become more complicated.

5. In some the cerebellum and olfactory lobes have even diminished in size.

He also finds some evidence that the same general law holds good for birds and reptiles from the Cretaceous to the present time.[1]

Thus we have in other groups as well as man convincing proof that, with successive survival of forms, there is a corresponding survival of larger brains.

Prof. Shaler[2] has offered some suggestive thoughts in showing the intense selective action which must have taken place in the shape and character of the pelvis in man, on his assumption of the erect position—the caudal vertebræ turning inward; the lower portion of the pelvis drawing together to hold the viscera, which had before rested on the elastic abdominal walls; the attending difficulties of parturition, and other troubles in those parts—all pointing to the change which has taken place.

In this connection Prof. Shaler remarks that the question of labor in woman must not be overlooked from this standpoint.

In a memoir on the shell-heaps of Florida, by Prof. Wyman, wherein he describes a number of low characters in man already alluded to, he gives the following conclusions: "The steady progress of discovery justifies the inference that man in the earlier periods of his existence, of which we have any knowledge, was at most a savage, enjoying the advantage of a few rude inventions. According to the theory of evolution, which has the merit of being based upon, and not inconsistent with, the observed analogies and processes of Nature, he must have gone through a period, when he was passing out of the animal into the human state, when he was not yet provided with tools of any sort, and when he lived the life of a brute."[3]

[1] *American Journal of Science*, vol. xii., July, 1876.

[2] "Proceedings of the Boston Society of Natural History," vol. xv., p. 188.

[3] "Memoirs of the Peabody Academy of Sciences," vol. i., part iv.

These words have no obscure significance, and when we regard the character of the one who wrote them, his cautious methods of research, and the long deliberation he was wont to give to all such questions, then they become doubly important.

Recognizing clearly the existence of these lower and earlier stages in man, it has been one of the most difficult problems to solve the first steps toward his society and family relations. Prof. John Fiske, in his "Outlines of Cosmic Philosophy," has given for the first time a rational explanation of the origin and persistence of family relations, and thence communal relations, and, finally, society.

Never before has there been presented so clear an idea of man's physical changes, and the effects of natural selection in seizing upon attendant or correlated nervous changes, as in the work of this author.

Prof. Fiske says: "Civilization originated when in the highest mammals variations in intelligence became so much more important than variations in physical structure that they began to be seized upon by natural selection, to the relative exclusion of the latter." [1]

Starting from the researches of Sir Henry Maine, Lubbock, and others, he finds social evolution must have originated after families temporarily organized among the higher mammals had become permanently organized. But how this step was effected has been an insoluble problem. Bagehot, in his remarkable work on "Physics and Politics," says: "It is almost beyond imagination how man, as we know man, could by any sort of process have gained this step in civilization." Darwin supposes that men were originally weak and inoffensive creatures, like the chimpanzee, and were compelled to band together to make up in combined strength what they lacked as individuals.

That man, for his age, is a weak animal physically, there can be no doubt. Fiske shows that "increase of intelligence in complexity and specialty involves a lengthening of the period during which the nervous connections involved in ordinary adjustments are becoming organized." From these conditions arose the phenomena of infancy, and he shows that with increase of intelligence infancy becomes longer. In the human race it is longer than in any other mammal, and much longer in civilized man than in the savage.

In the orang-outang the infant does not begin to walk till it is a month old, and in performing this act it holds to various objects for support, as in the human infant. Previous to that time it reposes on its back, and becomes absorbed in gazing at its hands and feet. Now, still lower down among the monkeys, at the age of one month the young are fully matured so far as walking and prehension are concerned. It is shown, furthermore, that where infancy is very short, parental feeling may be intense for a while, but soon dies out,

[1] "Cosmic Philosophy," vol. ii., p. 340.

and the offspring of one becomes of no greater interest than those of a stranger, "and in general the duration of the feelings which insure the protection of the offspring is determined by the duration of the infancy. . . .

"Hence if long infancies could have suddenly come into existence among a primitive race of ape-like men, the race would have quickly perished from inadequate persistence of parental affection." Prof. Fiske, in a most reasonable way, shows that "the prolonged helplessness of the offspring must keep the parents together for longer and longer periods in successive epochs; and when at last the association is so long kept up that the older children are growing mature while the younger ones still need protection, the family relations begin to become permanent. The parents have lived so long in company that to seek new companionships involves some disturbance of ingrained habits, and meanwhile the older sons are more likely to continue their original association with each other than to establish associations with strangers, since they have common objects to achieve, and common enmities bequeathed, inherited or acquired with neighboring families."

In his chapter on the moral genesis of man Fiske maintains that "the prolongation of human infancy accompanying the development of intelligence, and the correlative extension of parental feeling, are facts established by observation wherever observation is possible; and to maintain that the correlation of these phenomena was kept up during an epoch which is hidden from observation, and can only be known by inference, is to make a genuine induction, involving no other assumption than that the operations of Nature are uniform. To him who is still capable of believing that the human race was created by miracle in a single day, with all its attributes, physical and psychical, compounded and proportioned, just as they now are, the present inquiry is of course devoid of significance. But for the evolutionist there would seem to be no alternative but to accept, when once propounded, the present series of inferences."

Recalling now the various evidences educed by Wyman, Giman, and others, regarding the anomalous characters of the remains of primitive man, it seems impossible that a mind unbiased by preconceived opinion should be able to resist the conviction as to man's lowly origin.

If we take into account the rapidly-accumulating data of European naturalists concerning primitive man, with the mass of evidence received in these notes, we find an array of facts which irresistibly point to a common origin with animals directly below us, and these evidences are found in the massive skulls with coarse ridges for muscular attachments, the rounding of the base of the nostrils, the early ossification of the nasal bones, the small cranial capacity in certain forms, the prominence of the frontal crest, the posterior position of

the *foramen magnum*, the approximation of the temporal ridges, the lateral flattening of the tibia, the perforation of the humerus, the tendency of the pelvis to depart from its usual proportions, and, associated with all these, a rudeness of culture and the evidence of the manifestation of the coarsest instincts. He must be blind indeed who cannot recognize the bearing of such grave and suggestive modifications. But what application are we to make of such revelations if we vividly receive them as such? We are no longer to rest with the blind fatalism of the Turks, or listless resignation of the masses, but are to make a living use of them. We are to trace evil and corrupt passions to their source. The dreadful outrages which shock us from time to time in the public prints are not instigated by an evil spirit, but are outbursts of the same savage nature which found more frequent expression years ago, and which are still present with the lower races of to-day. When the study of heredity reveals the fact that even the nature of vagabondage is perpetuated; when the surprising revelations of Margaret, mother of criminals, from whose loins nearly a thousand criminals have thus far been traced, are considered, common-sense will ultimately recognize that the imprisonment of a criminal for ten or twenty years is not simply to punish him or relieve the public of his lawless acts, but to restrain him from perpetuating his kind. No sudden revulsion of feelings and amended ways is to purify the criminal taint, but he is to be quarantined in just the same way that a case of the plague might be, that his kind may not increase. With these plain facts thoroughly understood, men high in authority must find some other excuse for the exercise of their pardoning power, and other reasons be given for allowing so large a proportion of criminals to go free. With the monstrous blot of Mormonism and free-love in our country, the statute-books are to be again revised from the standpoint of science, with its rigid moral and physical laws, and not from the basis of established usage or long-continued recognition.

## THE LAWS OF HEALTH.

By THOMAS BOND, F. R. C. S.

ON an average, one-half of the number of out-patients treated by a hospital-surgeon suffer from diseases due primarily to a want of knowledge of the laws of health and cleanliness. 1. The ignorance of hygienic laws, which affects so disastrously the health of the rich as well as the poor, exists chiefly in regard to dress, ablution, and ventilation. This statement may, at first, appear startling, but an enumeration of the diseases that can be constantly traced to the above causes will show upon how sound a basis the statement rests. The